Laparoscopic aortofemoral bypass grafting: Human cadaveric and initial clinical experiences

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Purpose: **Postoperative complications are mainly related to the surgical trauma derived from the extensive abdominal incision and dissection after a conventional aortofemoral bypass grafting procedure. In an attempt to reduce postoperative complications, a concept of video-endoscopic vascular surgery on the infrarenal aortoiliac artery has been developed. On the basis of our experience with the practicability of video-endoscopic vascular surgery in the pelvic region in an animal study and in a pilot study of human cadavers, the purpose of this report was to describe three different methods that we evaluated on human cadavers and that we partly applied to patients.**

Methods: **In this experimental study, three different approaches were used to perform video-endoscopic aortofemoral bypass grafting. We performed an observational trial on human corpses (n = 24) with the transabdominal-retroperitoneal approach (TARA), the extraperitoneal approach (EPA), and the transabdominal left paracolic approach (TAPA). The EPA also was applied to patients with aortoiliac occlusive diseases.**

Results: **The TARA on cadavers (n = 4) soon was abandoned because it caused a burdensome sliding of the intestine into the operative field adjacent to the renal vessels, particularly in cases with obese subjects. In comparison, the TAPA (n = 6) with right-sided positioning of the patient retained the intestine in the right upper abdomen throughout the procedure. Until a surgeon actually is acquainted with the anatomic landmarks and the laparoscopic preparation technique, the EPA (n = 14) is a challenging procedure that necessitates thorough training. As with the TAPA, the EPA represents a procedure that reveals constant exposure of the operating field, even in cases with obese subjects. In the clinical observational study (n = 7), aortobifemoral bypass grafting was achieved totally laparoscopically with the EPA. The mean operating time was 6.5 hours and ranged from 3 to 10 hours. Blood transfusions were necessary after surgery in three patients (range, 1 to 3 red packed blood cells). One patient, who had had occlusion of the inferior mesenteric artery, died of ischemic colitis at postoperative day 10. The other patients had uneventful postoperative courses with minor wound discomfort.**

Conclusion: **Laparoscopic vascular surgery seems to be a promising procedure to minimize postoperative complications. On the basis of our experience, we do not favor the TARA. Because it necessitates steep Trendelenburg positioning to displace intra-abdominal organs, the TARA is not an appropriate approach, particularly in obese and cardiopulmonary frail cases. Contrarily, the TAPA and the EPA deliver potentially better results in terms of exposing the operative field and thus reducing operating time and perioperative morbidity rates. A prospective cadaveric and clinical trial may be justified to further evaluate the use of these surgical techniques. (J Vasc Surg 1999;29:639-48.)**

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Aortofemoral bypass grafting is a standard and well-established method for managing aortoiliac atherosclerotic occlusive disease that is either not amenable to percutaneous transluminal procedures or not infrequently the result of iatrogenic occlusion after arterial catheterization. Transverse incisions and extraperitoneal approaches have been proposed to alleviate pain and the concomitant postoperative complications. Nevertheless, neither approach has

Table I. Setup of the present video-endoscopic aortoiliac surgery project

Training model (n = 121)	*Cadaveric trial (n = 24)*	*Animal study (n = 25)*	*Clinical experience (n = 7)*
Patching	patching	TARA	EPA
End-to-side anastomoses	aortobifemoral bypass grafting	EPA	
	TARA	aortofemoral bypass grafting	
	TAPA		
	EPA		
End-to-end anastomoses			

TARA, Transabdominal-retroperitoneal approach; *EPA,* extraperitoneal approach; *TAPA,* transabdominal left paracolic approach.

been shown to have a significant advantage over the xiphopubic, transperitoneal incision.[1] The fact that operative morbidity (2% to 3% among experienced surgeons) and other typical postoperative complications[2,3] mainly are related to the surgical trauma derived from the extensive abdominal incision and dissection and not to the classical arterial reconstruction itself has led us to develop a laparoscopic aortoiliac surgical method that may diminish the risk of postoperative complications. Thus, our basic concept of this new method for video-endoscopic aortoiliac reconstruction is to supplement the excellent 5-year patency rates of more than 90% after conventional arterial reconstruction with the advantages of the video-endoscopic abdominal approaches (ie, inflicting less trauma to the abdominal wall, reduced pain, quicker gastrointestinal motility, lower infection rates and potentially reduced cardiopulmonary complications, reduced sexual dysfunctions, and shorter hospitalization periods).

The purpose of this report is to describe the different video-endoscopic methods that we have adopted on human cadavers and patients and to point out some of the pitfalls that we have encountered. Because we believe that special instrumentation for video-endoscopic vascular surgery in the pelvic region is not available yet, new instrument sets for video-endoscopic vascular surgery have been designed by S. Said since 1992 in close cooperation with Aesculap AG & Co KG Company, Tuttlingen, Germany.

MATERIALS AND METHODS

The basic techniques of laparoscopic end-to-side and end-to-end anastomosis (Table I) were evaluated with the newly designed instruments (Fig 1) on a training model (n = 121). In an attempt to study the technical feasibility of laparoscopic aortofemoral bypass grafting surgery, a human cadaveric study was performed for the evaluation of three different approaches. Thus, the transabdominal-retroperitoneal approach (TARA), the extraperitoneal approach (EPA), and the transabdominal left paracolic approach (TAPA) were tried on 24 human corpses. The positive results of the survey with the training model, regarding operating time and the easy handling of the newly developed instruments from an ergonomics point of view, encouraged us (with institutional approval) to apply the EPA on seven patients with occlusive diseases of the aortoiliac vessels. All cadaveric and clinical procedures were performed by the first author. The results of our animal studies will not be included in this report because they have been published previously.[4]

The outcome measure of the human cadaveric study included, besides the total operating time in performing aortofemoral bypass grafting, the ability to dissect the aorta up to the renal vessels with different laparoscopic approaches and the ability to expose the adjacent structures, such as the sympathetic nerves, the ureter, and the inferior vena cava. Because one of the major concerns regarding the EPA is obtaining control of the contralateral iliac artery to safely pull the right limb of the bifurcated graft beneath the ureter, the frequency of obtaining control of the contralateral right iliac artery from the left EPA was recorded.

In the clinical observational study, the outcome measure was the feasibility of performing totally laparoscopic aortofemoral bypass grafting with the EPA on patients with aortoiliac occlusive diseases who were not amenable to endoluminal procedures. Furthermore, its effects on intraoperative and postoperative variables were recorded.

Patients at cardiopulmonary high risk were excluded from the observational study. The data analyzed included laparoscopic operative times, blood loss, aortic clamp time, requirement of blood transfusion, intraoperative fluid requirements, and duration of nasogastric suction. The length of stay in the intensive care unit was not included in the outcome measures because laparoscopic video-endoscopic aortoili-

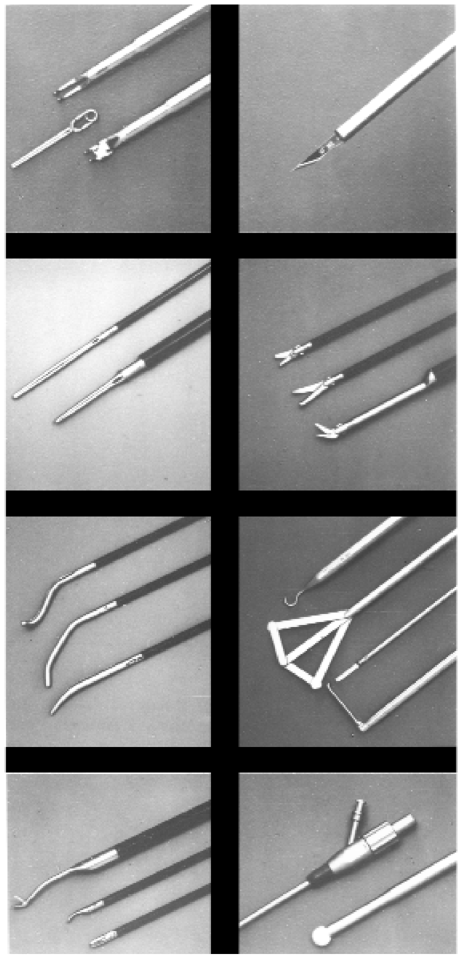

Fig 1. Main elements of new instrument set for laparoscopic aortoiliac surgery.

ac surgery was still regarded as an experimental clinical procedure. The patients were discharged after the control angiography and the healing of the inguinal wounds. Only descriptive statistics were used.

Transabdominal-retroperitoneal approach. The human cadavers (n = 4) were placed in a supine position on the operating table with the legs abduced. The operating surgeon was positioned between the legs, and the camera holder (first assistant) stood to the right of the subject. A second assistant was situated to the left of the subject. A 1-cm subumbilical incision was made, and a 10-mm port was introduced under direct vision for laparoscopic visualization of the abdominal cavity, which was insufflated with carbon dioxide to a pressure of 12 mm Hg. The table was tilted in a 30-degree Trendelenburg (head-down) position. With direct laparoscopic visualization (with a 30-degree view), five additional 10-mm trocars were inserted as outlined in Fig 2. First, the intestine was gathered to the right upper abdomen with the three-blade intestinal retractor (Aesculap AG & Co KG Company), which was fixed to the self-retaining double ball-and-socket joint holder. Then, the incision of the retroperitoneum overlying the anterior wall of the aorta was made. The origin of the inferior mesenteric artery was noted but not dissected. The anterior and lateral walls of the aorta were dissected to expose the aorta up to the level of the left renal vein. Then, the aorta was occluded just below the left renal vein with the aortic clamp. Distal clamping was performed in an oblique direction with the crawford clamp so that the lumbar arteries were also occluded. Alternatively, a laparoscopic Satinsky clamp was introduced through the suprapubic trocar site to clamp the aorta. Incision of the aorta between the left renal vein and the inferior mesenteric artery was followed by a 4-cm arteriotomy with the curved scissors. Subsequently, an extracorporally adjusted Dacron graft (16/8 mm; Meadox Medicals, Inc, Oakland, NJ) was inserted

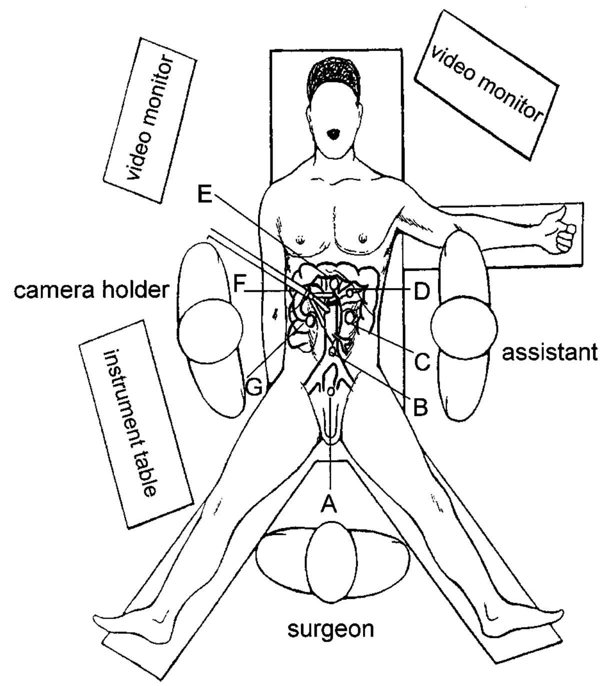

Fig 2. Placement of trocars for laparoscopic aortofemoral bypass grafting with transperitoneal-retropertitoneal approach. *A,* Crawford clamp, alternatively Satinsky clamp; *B,* camera; *C,* needle driver, scissors, dissector; *D,* suction irrigator; *E,* aortic clamp; *F,* bowel retractor, *G,* suture holder, dissector.

through one of the trocars. The aortic anastomosis was performed with a single, double-ended, running 3-0 Prolene suture, which was started at the distal corner of the arteriotomy. Both ends of the thread were tied together intracorporally. No assistance was needed to hold the anastomotic suture tight. After the removal of the clamps, gentle blunt dissection was used to create a tunnel into the retroperitoneal space anterior to the iliac arteries. Both limbs of the prosthesis were brought to the femoral region under laparoscopic vision with a grasper inserted through the groin incisions. The retroperitoneum then was closed with a running suture laparoscopically. Finally, the femoral end-to-side anastomosis was performed in a conventional manner.

Extraperitoneal approach. The EPA was used in 14 human cadavers and in seven clinical patients. The patient for the extraperitoneal route was positioned on the operating table in the right lateral decubitus position, with the pelvis twisted towards the horizontal line. The table was fully broken and initially tilted to the right side to displace the intra-abdominal organs from the operative field relying on gravity. Trendelenburg positioning was not necessary. The operating surgeon was positioned to the back of the patient, and the camera holder (assistant) stood to the left of the operating surgeon. The monitor was positioned on the opposite side of the operating table (Fig 3). After a 20-mm cut down at the mid-axillary line halfway between the costal margin and the anterior superior iliac crest, the incision then was deepened with conventional scissors. The three muscle layers of the abdominal wall gradually were split until the fascia was exposed. This then was incised to enter the retroperitoneal space, which then was carefully dissected digitally. The peritoneum was identified and was swept medially with the index finger. Dissection was followed by the insertion of the balloon trocar system (Braun AG, Melsungen, Germany) through the initial abdominal incision with simultaneous endoscopic vision. This allowed separation of the peritoneum and thereby exposed the lower retroperitoneal space. The balloon trocar then was exchanged for a 10-mm cannula, and the retroperitoneal space was insufflated with carbon dioxide, with a maximum pressure of 12 mm Hg. Then, a 30-degree endoscope was inserted, and the lower retroperitoneal space was exposed. Next, the remaining four to five ports were placed under laparoscopic vision as illustrated in Fig 3. One 12-mm working port was located on the anterior axillary line directly below the left costal margin (for dissection and suturing), and one port was placed on the anterior axillary line halfway between the costal margin and the left iliac crest (for dissection, suctioning, and grasping tissue). One 10-mm port was positioned at the mid-clavicular line about 5 cm above the left inguinal ligament for the displacement of the abdominal organs with the three-blade retractor. A double ball-and-socket joint holder was attached on the left side of the operating table to fix the intestinal retractor at the desired position. In four cases, an external two-blade abdominal lift device (Aesculap AG & Co KG Company) was applied through this incision to maintain the working space for gasless video-endoscopic aortoiliac surgery. One port was placed at the left subcostal incision at the posterior axillary line for the cross-clamping of the infrarenal aorta. One port was alternatively placed adjacent to the left iliac crest at the posterior axillary line for the distal clamping of the aorta, as shown in Fig 3.

The video-endoscopic access that we have used in human cadavers and clinical patients with carbon dioxide inflation to approach the aortoiliac vessels up to the renal vessels can be outlined as follows.

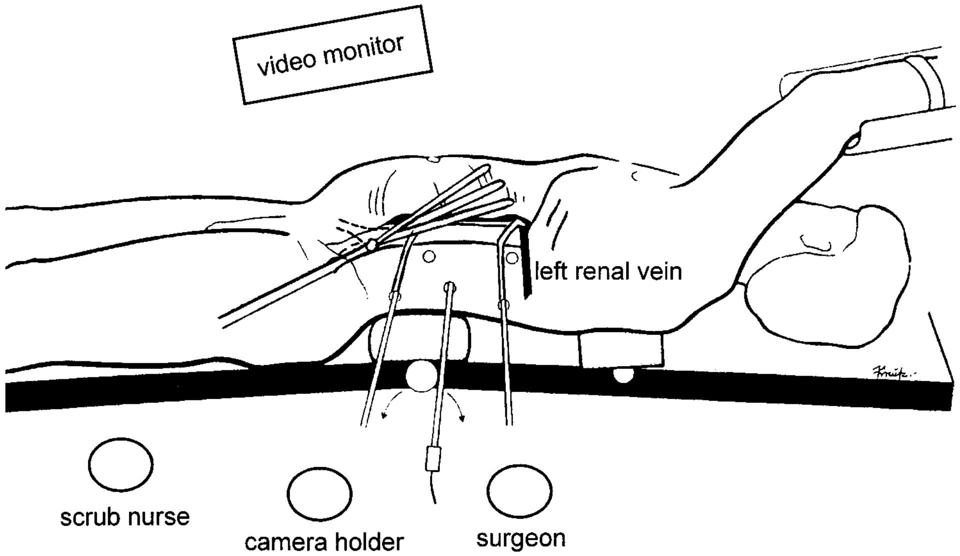

Fig 3. Positioning of patient, surgical team, equipment, and trocar sites during laparoscopic aortoiliac surgery with extraperitoneal approach.

With further dissection, with scissors and bluntly with a suction irrigator, the descending colon and sigmoid was reflected medially in the plane between Gerota´s (perinephric) fascia and the mesentery of the colon. The first landmarks consist of the left psoas muscle, the iliac artery, and the ureter. We furthermore have considered the spinal column, which can easily be palpated with a sponge as a landmark, to trace the aorta upwards from the iliac artery. Adequate exposure of the para-aortic region proximal to the inferior mesenteric artery and up to the immediate left suprarenal aortal segment was obtained by gently pressing aside the left kidney and the adjacent viscera with the adjustable three-blade retractor. In patients, 5000 IU of heparin were administered intravenously before the crossclamping of the infrarenal aorta with the Satinsky clamp, which was introduced through the left subcostal incision at the posterior axillary line. This enhanced the lifting up of the aorta to expose the lumbal arteries, which were occluded with titanium clips. The distal clamping of the aorta then followed proximal to the mesenteric artery with the crawford clamp introduced through a separate port adjacent to the left iliac crest at the posterior axillary line. Alternatively, in the case of low calcification in that region, distal occlusion of the aortic segment proximal to the inferior mesenteric artery was achieved with the self-retaining vessel clamp, thus omitting the additional port for distal aortic clamping. Then, the incision of the aorta with the retractable knife and the

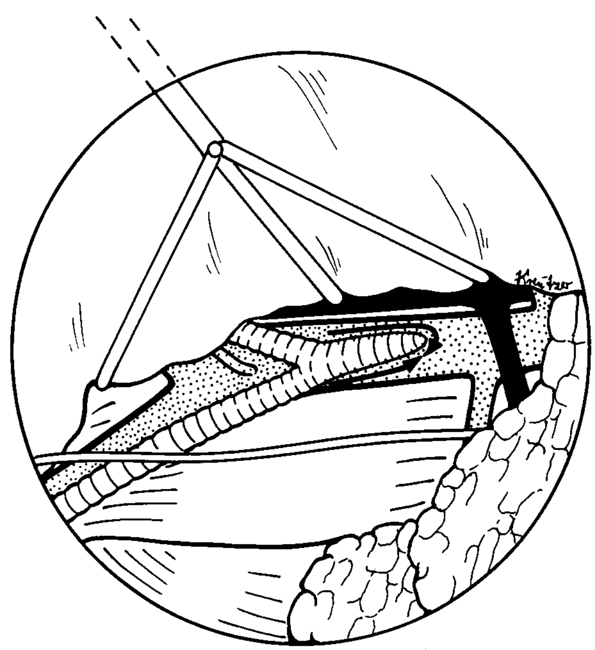

Fig 4. Principle of laparoscopic end-to-side aortic anastomosis, with double-needle Prolene suture. Both ends of continuous suture are knotted intracorporally at front site of arteriotomy, as indicated by *arrows*.

subsequent aortotomy with the curved scissors followed. An extracorporally adjusted (16-mm/8-mm) Dacron bifurcation graft (Meadox Medicals Inc) was inserted through one of the trocars. The end-to-side anastomosis was performed with a single (3-0

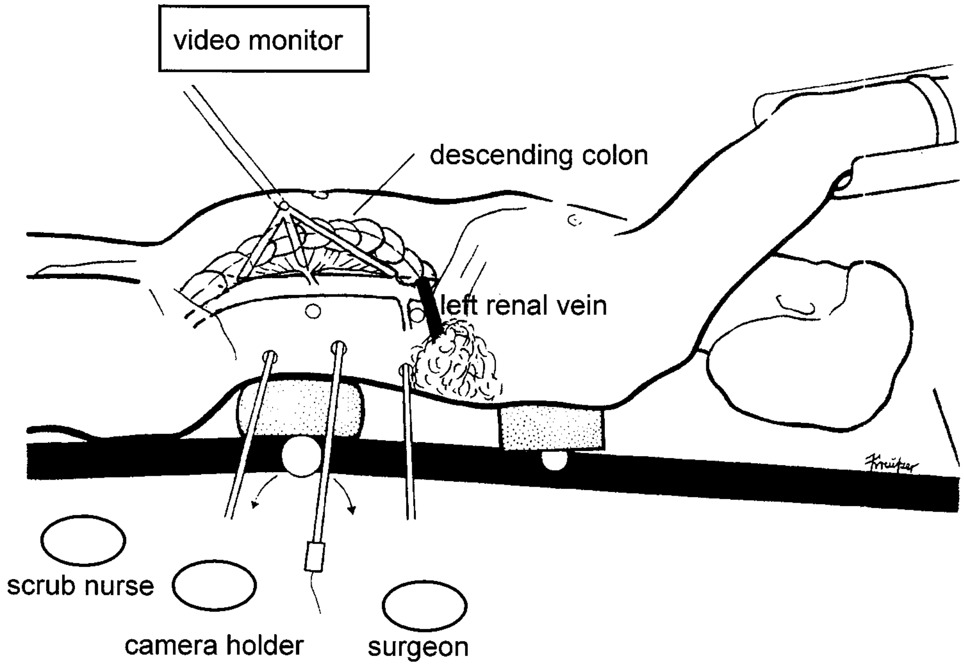

Fig 5. Placement of trocars for laparoscopic aortofemoral bypass grafting with transabdominal paracolic approach.

Prolene double-arm) running suture according to the rules of classic vascular surgery and started at the distal corner of the aortotomy (Fig 4). The tissue bites of the front site of the arteriotomy were taken in a forehand manner and the backside in a backhand manner, and both ends of the suture were knotted intracorporally at the front site of the arteriotomy. No assistance was needed to hold the anastomotic suture tight. Suctioning was performed intermediately by the operating surgeon. After the unclamping and checking of the integrity of the anastomosis, gentle blunt dissection was used to create a tunnel into the retroperitoneal space anterior to the right iliac artery. This was done to exteriorize the right limb of the bifurcated graft to the femoral artery beneath the ureter under controlled vision. Alternatively, the right limb of the bifurcated graft was brought down to the groin extraperitoneally across the retropubic prevesical space of Retzius. Finally, after both limbs of the graft were brought to the groins, the graft was anastomosed to the femoral arteries with a 5-0 Prolene suture in a standard open fashion.

Transabdominal left paracolic approach. To study the TAPA (n = 6), the human cadaver was placed on the operating table also in a right lateral decubitus position as with the EPA. The trocar placements with the TAPA were similar to the placements with the EPA—the only difference was that in the TAPA technique the ports did not have to be placed as lateral as in the EPA because the strong anterior peritoneal attachment to the rectus was not an issue for the TAPA (Fig 5). After balloon dissection of the left extraperitoneal space, as described above, the abdominal cavity was entered by dividing the lateral peritoneal attachment of the descending colon from the left flexure of the colon all the way into the pelvis. The previous balloon dissection of the extraperitoneal space and the tilting of the patient to the right facilitated the medial reflection of the descending colon in the plane between Gerota´s fascia and the mesentery of the colon. This finally revealed the midline retroperitoneal structures, such as the aorta, all the way up to the left renal vein, the inferior vena cava, the sympathetic nerves, and the left ureter. The rationale of the TAPA was to transabdominally expose the aorta with the mesentery of the descending colon used to facilitate retraction of the small bowel to the right, thus eliminating the burdensome sliding of the small intestine. In addition, retaining the displaced intraabdominal organs was achieved relying on gravity by tilting the patient to the side. The further surgical steps (cross clamping, aortal anastomosis, exteriorizing the limbs of the bifurcated graft) were performed according to the guidelines that have been described in the EPA technique.

RESULTS

Human cadavers

Transabdominal-retroperitoneal approach. The use of the TARA on cadavers (n = 4) was soon abandoned because it caused, especially in obese cases, the sliding of the intestine and the greater omentum into the operative field, which resulted in frequent changes of instruments and patient positioning and thus created prolonged operating times (average time, 7 hours; range, 6 to 8 hours). Thus, the steep, head-down positioning of the obese cadavers and the usage of the three-blade retractor did not facilitate a constant view of the operating field as a result of the short mesentery in three obese cases. The repeated shifting of the abdominal viscera was necessary in these cases eight to 12 times during the procedure. Therefore, in two cases, we performed the aortic anastomoses distal to the inferior mesenteric artery because in these cases we were not able to constantly expose the aorta up to the left renal vein. On the other hand, the dissection of the aorta up to the renal vessels and the exposure of the adjacent organs and the performance of aortofemoral bypass grafting was easily achieved in a thin human cadaver (total operating time, 2 hours), relying on adequate pneumatic distention of the abdomen in the TARA technique.

Extraperitoneal approach. As part of a feasibility study, we used the EPA in 14 human cadavers. Ten cases were performed with a pneumoretroperitoneum technique throughout the operation. As we gained more experience in the dissection of the extraperitoneal cavity to achieve an adequate working space, the time necessitated to perform aortofemoral bypass grafting decreased progressively from 5 hours to 2.5 hours (average time, 3.8 hours). Our acquaintance with the extraperitoneal anatomy, the alteration of the port sites, and the refinement of our instruments enabled us to accomplish sound aortic end-to-side anastomoses of an aortofemoral bypass graft within an average of 32 minutes (range, 10 to 90 minutes). In five of 14 EPA cases, possibly as a result of autolysis of the human cadaver, we encountered rupturing of the peritoneum while dissecting the extraperitoneal space. In 11 of 14 cases, the aorta was dissected up to the renal vessels to obtain an adequate view of the adjacent organs (eg, sympathetic nerves, the left ureter, and the inferior vena cava). Control of the contralateral right iliac artery from the left EPA was obtained in 10 of 14 cases. In these 10 cadavers, the right retroperitoneal space was exposed up to the right external artery and the ureter. That enabled us to pull through the right limb of the bifurcated graft to the femoral arteries beneath the ureter with controlled vision. In the remaining four cadavers, the right limb was brought down through the prevesical retropubic space of Retzius.

In four cases with the EPA, we applied an abdominal wall retractor without a pneumoretroperitoneum technique after the exposure of the operative field. Regarding gasless EPA, we realized that working with the two-blade abdominal wall retractor created a more restricted operative field, which thus lengthened the operating time by 45 minutes on the average (average operating time, 4.5 hours; range, 3.5 to 6.3 hours).

Transabdominal left paracolic approach. In comparison, the TAPA that we have recently adapted with a pneumoperitoneum technique in human cadavers (n = 6) offered a relatively vast operative field. We realized a comparatively fast learning curve, which is indicated by an operating time of only 2.5 to 3.5 hours already (average, 2.9 hours). Because of the vast operating field encountered in the TAPA, there were no difficulties in the dissection of the aorta up to the renal vessels. The constant exposure of the adjacent organs and the performance of aortofemoral bypass grafting was readily achieved even in four obese cases.

Patients

Extraperitoneal video-endoscopic aortobifemoral artery bypass grafting procedures (EPA) were performed in seven patients with aortoiliac occlusive diseases who were not amenable to endoluminal procedures (after institutional approval, all the patients gave informed consent). The laparoscopic operations were all performed with a carbon dioxide pneumoretroperitoneum technique with the video-endoscopic vascular instrument set that was designed by the first author. In three cases, exposure was hampered by difficulties with the adequate retraction of the viscera as a result of the accidental tearing of the peritoneal sac. The intra-abdominal gas had pressed the peritoneum into the operative field. Venting the abdominal cavity with an additional cannula into the abdomen only minimally improved the exposure of the extraperitoneal space. However, technical success was achieved in all the patients, with an average laparoscopic operating time of 6.5 hours (range, 3 to 10 hours). Aortic cross clamp time averaged 59 minutes (range, 45 minutes to 110 minutes). No conversion to laparotomy was needed. Primary integrity of the anastomosis was achieved in four cases. Three anastomoses necessitated additional sutures. Intraoperative requirements averaged 7 ± 1.4 L of crystalloid and 1 unit of packed red cells. During surgery, blood loss averaged 0.5 L (range, 0.2 to 1.5 L). No patients had massive hemorrhage caused by large vessel injury during the operation. The length of the stay in the intensive care unit ranged from 1 to 3 days (average, 1.5 days), and nasogastric suction was maintained for 1.5 days. One 68-year-old patient, in whom we had occluded the inferior mesenteric artery, died after an initial uncomplicated postoperative course on the 10th postoperative day as the result of ischemic colitis. Ischemic colitis occured even though we had checked the integrity of the intestine during surgery by placing an additional port into the abdominal cavity. The other patients had an uneventful early postoperative course, with minor wound discomfort that was indicated by the lower consumption of analgesics in comparison with the patients who underwent conventional transabdominal or retroperitoneal aortofemoral bypass grafting at the same institution. All the patients tolerated oral intake within 24 hours. The average hospital stay was 6.2 days and ranged from 3 to 14 days.

DISCUSSION

Reconstruction surgery of aortoiliac occlusive disease has generated long-term patency rates and satisfactory results. The high 5-year patency rate of the aortofemoral and the aortoiliac prosthesis of 70% to 90% has accorded this surgical procedure full recognition.[5-9] Inspite of superior surgical techniques and perioperative monitoring, the conventional method is associated with frequenct early and late complications because of its traumatically invasive nature. These problems gave rise to the idea of devising an alternative surgical technique.[4,10-13] Thus, the basic concept of this new method for video-endoscopic aortofemoral reconstruction is to supplement the excellent 5-year patency rates of more than 80% after conventional arterial reconstruction with the advantages of the video-endoscopic abdominal approach. These advantages are: less trauma, reduced pain, quick gastrointestinal motility, reduced cardiopulmonary complications, reduced infection rates, and potentially less sexual dysfunction. The rate of postoperative wound infection and cicatricial hernia is around 5%.[14] However, in endoscopic surgery, these complications only play a minor role.[15,16] With the newly developed instruments, the infrarenal aorta and the iliac artery could be exposed by five to six trocars with a diameter of 10 to 12 mm. On the basis of experience from laparoscopic gastrointestinal surgery, it is notable that early postoperative motility of the stomach and intestine represents a typical phenomenon of this surgical method.[17,18] This was observed in the few patients who successfully underwent operations and also by other authors who have indicated that patients after laparoscopic aortic surgery had a faster recovery time than did patients after conventional surgery.[19,20]

Weber et al[11] reported on a video-controlled minimal invasive exposure technique of the abdominal aorta. A video-assisted implantation of an aortobifemoral prosthesis with seven 10-mm trocars was performed by another group.[10] The prosthesis implantation into the aorta was completed by performing an 8 cm–long medial incision. The same authors meanwhile have performed aortobifemoral bypass grafting procedures in piglets and patients with the complete retroperitoneal laparoscopic approach.[20] In comparison, our procedure represents a laparoscopic method without the need of any operative incision. The operation is performed exclusively through trocars by means of newly developed instruments, whereby trauma of the abdomen and the surgical preparation is potentially still further reduced. Experience in laparoscopic colon surgery, which has a sparing endoscopic preparation technique and a high endoscopic magnifying effect, shows that the preaortal sympathetic fibers can be well exposed and prepared when necessary. Through this step, it is likely that the neurogenic-induced sexual dysfunction can be drastically reduced with endoscopic vascular surgery. The experiences from our experimental investigations have clearly shown that the field of operation, especially the vascular wall, can be illuminated from different directions with high magnification. On the basis of the first author's[21] sound long-term experience in suturing intestine with stereoscopic control in more than 400 patients, suturing in vascular surgery with a three-dimensional image would most probably simplify and speed up the operation. So far, the animal studies we have conducted[4] have shown that the magnified video-endoscopic exposure of the aortoiliac vessels, adequate clamping, correct arteriotomy, and hemodynamically correct vascular reconstruction is feasible.

Because video-endoscopic suturing necessitates intensive practice and a high degree of coordination, the development of adequate stapling devices would be desirable. Nevertheless, vascular stapling devices could potentially fail in performing anastomoses in heavily diseased arteriosclerotic vessels.[22] Because intracorporal knot tying and the performance of a running suture with the available instruments is cumbersome and time consuming for surgeons who are inexperienced laparoscopically, we currently are evaluating our newly designed needle holder that enables extracorporal knotting and continues suturing without the adverse effects of surplus suturing material in the limited abdominal cavity. Microscopically, no suture disruption or traumatization of the vessel or the suture occurred with the newly developed rubber-shod suture holder. Contrarily, severe traumatization on suture materials were to be seen microscopically with conventional endoscopic needle holders, which led to disruptions of the sutures after a different expansion length as indicated on the tensometric trials that we have conducted (unpublished data).

The intensive investigation that we have performed on human cadavers meanwhile enabled us to always expose the aorta above the level of the inferior mesenteric artery and up to the left renal vessels. This exposure was only achieved by gaining familiarity of the video-endoscopically exposed retroperitoneal anatomical structures. In addition, we have realized that digital dissection is sufficient to create an initial working space for the introduction of the trocars extraperitoneally with digital guidance, which thus avoids the relatively costly balloon trocar system. We suggest that even patients who are obese and those patients with previous abdominal surgery are suitable for the EPA. On the other hand, it seems to be that, at the present stage, obesity and previous abdominal surgery is a contraindication for the transperitoneal access, as a result of the burdensome sliding of the intestine into the operative field, as mentioned by other surgeons who clinically practice the TARA. It is to be hypothesized that, through the TARA, the anastomosis of the graft adjacent to the renal vessels, as is indicated in classical surgery, can cause severe difficulties in cases where the inferior mesenteric artery is located in the proximal region of the abdominal aorta. On the other hand, a considerable advantage of the TARA is that it gives additional views of intraperitoneal viscera and contralateral iliac exposure. With the suggestion that the EPA is more demanding in the conception of the extraperitoneal anatomy with laparoscopic guidance, we recently have concentrated on the development of the TAPA, which presents a few similarities with the technique described by Dion and Gracia,[23] with the main difference being that in the TAPA technique the sectioned left paracolic peritoneum does not have to be sutured to the abdominal wall to keep the contents of the abdominal cavity off of the aorta. The TAPA necessitates the steep tilting of the patient to the right side and thus relies largely on gravity to displace intra-abdominal organs from the operative field. This surgical procedure will most probably supplement the advantages of the transperitoneal access with the EPA. The enlarged working space with the whole abdominal cavity, in combination with the constant exposure of the aortoiliac vessels, will probably enhance the transposition of the TAPA to human subjects with occlusive diseases and with aneurysms. Further cadaveric trials and clinical studies are yet to be performed before the strong recommendation of the TAPA.

It is generally accepted that no mechanical retraction system can compete with pneumoperitoneum technique regarding the exposure of the operative field because it creates a tent-shaped suspension with limited intra-abdominal working space.[24] Contrarily, the pneumoperitoneum technique provides a dome-shaped exposure with a wider instrumental motion range. One major concern in the steep, head-down positioning of the patient, which mainly causes prolonged intra-abdominal pressure with a pneumoperitoneum technique, is the adverse effects on cardiopulmonary, intestinal, and hepatorenal function as has been indicated by different authors.[25-27] As in vascular surgery, we are often dealing with patients who have poor homeostatic reserves and cardiopulmonary disease. Some patients are thought to be prone to severe hemodynamic side effects when applying prolonged pneumoperitoneum technique with an intra-abdominal pressure of even only 12 mm Hg.[28] A current discussion concerns increased intra-abdominal pressure that results in the reduction of cardiac preload (reduced venous return as a result of pmeumatic caval compression) with an increase of cardiac afterload (systemic vascular resistance increase). The death of our patient from ischemic colitis could possibly be partly related to the prolonged intra-abdominal pressure. Even though some authors indicate that "extraperitoneal insufflation might result in less cardiovascular impairment than intraperitoneal insufflation,"[29] we believe that, until surgeons achieve rapid and safe total video-endoscopic aortoiliac surgery with pneumoperitoneum technique in preclinical studies, the gasless approach with mechanical abdominal retractors or the laparoscopic assisted repair with a small abdominal incision for suturing with direct vision should be discussed as an intermediate step towards generalizing the total laparoscopic procedure. Future studies and the refinement of instrumentation is necessary to safely adapt the promising video-endoscopic aortoiliac surgery in humans, which should be performed only with research control.

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